PATENT SPECIFICATION

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369,333

COMPLETE SPECIFICATION.

Improvements in Power Plants.

We, KARL HAMM and KURT BEYRODT, both Citizens of Germany and Engineers, of 118—30, 155th Street, Jamaica, New York, and 530, Riverside Drive, New York City, United States of America, respectively, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to power plants of the continuous combustion type, and more particularly is directed to an improved method for converting the energy of continuously burning fuel into mechanical energy and to novel apparatus for practising the improved method, said apparatus and method herein described being particularly adapted to furnish motive power for transportation equipment.

It is contemplated in practising this invention to use power plant units arranged and operated in a novel manner in which fuel is continuously burnt to generate a steam supply for a turbine, the gases of combustion after generating the steam supply being further utilized by a gas turbine. In the method of operation here described an oil burner may be used to atomize and burn crude oil in a chamber under pressure greater than atmospheric. The heat extracted from the gases of combustion in passing through a boiler cools the gases sufficiently for practical use in the gas turbine, thus eliminating difficulty heretofore experienced with turbine parts exposed to combustion gases of high temperatures. One object of the invention is to provide and operate an improved power plant of the character described utilizing fuel combustion apparatus, boilers, gas and steam turbines, and condensers in novel combination whereby said power plant is made suitable to furnish motive power for vehicles, aeroplanes, dirigibles and the like.

Another object of the invention is to provide an improved method of the character described for converting the energy of continuously burning fuel into mechanical energy which is simple to carry out, the combustion of the fuel and conversion of the energy derived therefrom being carried out within the limits most practical and efficient for utilization by the units forming the power plant.

One feature of the invention is to bleed, that is, abstract steam from a comparatively high pressure stage of the steam turbine and utilize this bled steam to operate means for forcing the said water into the boiler. Steam turbine operation with a bleeder system increases the internal efficiency and permits decreasing the size of the cooling condenser equipment since said equipment need only be of sufficient size to handle the steam passing from the steam turbine. Heretofore the tremendous weight of apparatus using a steam plant, and particularly those including a condenser were not to be thought of as motor power for aeroplanes. It is still another object of the invention to provide a practical improved steam condenser type of power plant adapted to be used for aeroplane propulsion.

A further object of the invention is to provide an improved power plant of the character described comprising simple and novel arrangement of parts which shall form a compact, relatively lightweight apparatus, shall operate with very little attention requiring practically no skilled or expert supervision in operation, which shall reduce the vibratory stresses to a minimum, which shall be readily installed as a unitary structure, which shall be relatively inexpensive to manufacture and install, and practical and efficient to a high degree in use.

Other objects of this invention will in part be obvious and in part hereinafter pointed out.

The invention accordingly consists in the features of construction, combinations of elements and arrangement of parts which will be exemplified in the constructions hereinafter described and of which the scope of application will be indicated in the following claims.

In the accompanying drawings, in which is shown various possible illustrative embodiments of this invention,

Fig. 1 is a diagrammatic view showing the general layout of the power plant units

interconnected for practising the method embodying the invention.

Fig. 2 is a plan view, partly diagrammatic, showing the several power plant units arranged in axial alignment with the fuel combustion apparatus, boiler and interconnected units arranged for practising the improved method.

Fig. 3 is a cross-sectional view showing a novel compact arrangement of the rotary apparatus parts of the units, concentrically positioned about the fuel combustion unit and boiler, and exposing the interior construction of said units.

Fig. 4 is an end view as seen along lines 4—4 in Fig. 3.

Figs. 5, 6, 7 and 8 are cross-sectional views taken on lines 5—5, 6—6, 7—7, and 8—8, respectively, in Fig. 3, and

Fig. 9 is a detailed cross-sectional view showing the means for supporting the inner feed water supply tube within the outer steam tube and also showing the nozzle construction for spraying the feed water against the inner surface of the outer tube.

A novel power plant embodying this invention now to be described in detail includes in combination a gas turbine and a bleeder or extraction type of steam turbine, the unit being so arranged as to form an efficient power plant for aeroplanes, automobiles, and other purposes where an exceptionally light weight prime mover is desired. The principle idea of operating the improved power plant is as follows:

A reduction of the temperature of the gases to be used as medium for converting heat energy into mechanical energy in the gas turbine is obtained by extracting a certain amount of heat per unit volume of the gas in the combustion chamber and converting this heat by means of a steam boiler and a bleeder type of steam turbine into available mechanical energy. This reduction of temperature of the gases is essential and vital to the efficient and practical operation of the gas turbine since the materials forming the parts of the gas turbine are not capable of satisfactorily withstanding the excessive initial temperature of the gases in the combustion chamber. The method here used of reducing the temperature of the combustion gases for operating the gas turbine departs from the usual methods now employed in the arts, since heretofore the reduction of the temperature has been obtained by introducing excess air, steam or water to the combustion chamber. Under this usual method of reducing the temperature a gas turbine operates at a very low thermal efficiency, whereas the power plant in the present invention which requires no excess air, steam or water, permits reduction of size and weight of apparatus yet operates efficiently.

The use of the bleeder or extraction type of turbine reduces considerably the weight of condenser necessary to condense the steam, the latter being bled off from the turbine at one of the high pressure stages. The extracted steam is used to operate an injector for feeding the condensed water back into the boiler.

The improved power plant may be adapted to burn crude oil in a combustion chamber which is set within a helical tube boiler of the plate or flash type. The gas turbine receives the gases from the boiler, and the steam turbine is connected to the boiler. A turbine type of air compressor supplies air to the combustion chamber and the injector receives steam bled from the steam turbine for feeding condensed water passing from the condenser. The power generated by the turbines may be delivered to a propeller through a gear transmission. It is to be understood that mechanisms for automatically controlling the steam, air, oil and water supply of any standard, well understood construction may be provided on the power plant units.

Now referring to the drawing, Fig. 1, 10 denotes an improved layout of interconnected power-plant units in which the novel method for converting the energy of continuously burning fuel into mechanical energy embodying the invention, may be carried out. The power plant units 10 here shown comprise a suitable fluid pressure generator, such as a steam boiler 11, of the flash or hot plate type, a multistage turbine having a high pressure stage 12 and a lower pressure stage 13. A condenser 14 taking the exhaust steam from the lower pressure turbine stage 13 is arranged adjacent the turbine 12. The condensed water from the condenser 14 is fed back to the boiler 11 through an injector 15, the latter being operated by steam fed from the high pressure stage 12.

For heating the boiler, liquid fuel, such as crude oil, may be used and supplied from a convenient source 16 to a suitable burner 17 of any conventional make.

The partially cooled gases of combustion leaving the boiler are passed through a gas turbine 18 which supplements the available power or mechanical energy generated by the steam turbine portions 12 and 13, the power generated being utilized through a suitable transmission 19. Connected to turn with the rotary parts of the units there is a blower or compressor 20 which supplies air to the oil burner 17 and to a combustion chamber (shown in Fig. 3) within the boiler.

In Fig. 2 a practical layout of power plant units 10, partly diagrammatic, is shown which includes an electric motor drive 21 connected with the burner equipment. A reduction gearing, indicated at 22, is shown connecting the power transmission 19 with an aeroplane propeller 23.

Referring now to Figs. 3 to 9, inclusive, a novel compact combination apparatus 110 is shown constructed to embody the invention. Said apparatus 110 has the rotary parts of the units, concentrically arranged about the fuel combustion chamber 24 and boiler 11 which form an internal stator structure for the equipment shown. Said stator structure is enclosed in a horizontally disposed cylindrical casing 25 which has its flat and circular shaped ends 25a and 25b axially supported on spaced and aligned fixed shafts 26 and 27, respectively. The outer surface of the cylinder 25 has fixed thereto an annular shell 26^1 which carries along one end portion, radially outward extending stationary blades 18a of the gas-turbine unit 18; along the mid-portion thereof, the radially outward extending stationary blades 12a and 13a of the high and low pressure steam turbine stages 12 and 13, respectively; and at the other end portion of said shell 26^1, the radially outward extending stationary blades 20a of the air compressor 20. The channel 25c between the casing 25 and shell 26^1 forms a passage for air, steam and water conduits arranged in the manner hereinafter described.

An external rotor structure is seen to form an enclosure, surrounds the stator structure of the improved combustion apparatus 110, said enclosure comprising a horizontally disposed cylindrical shell casing 28, supported at its opposite ends by disc plates 29 and 30. The shell casing 28 is concentrically positioned with respect to the annular shell 26^1 and carries gas turbine, high and lower pressure steam turbine and air blower runners or blades 18b, 12b, 13b and 20b, respectively, complementary to said stationary blades 18a, 12a, 13a and 20a, respectively.

The discs 29 and 30 are mounted for revolving the shell casings 28 on the shafts 26 and 27, respectively, through suitable bearings, which preferably are of the anti-friction type, such as ball-bearings 31 and 32, respectively. The shaft 26 is fixedly supported on a stanchion 33 and the shaft 27 is supported within a sleeve 30a extending axially outward from the disc 30. The sleeve 30a may be supported upon a suitable fixed base (not shown) through a bearing, also preferably of the anti-friction type, such as ball-bearing 34.

The fuel combustion chamber 24 which extends axially partially the length of the stator structure has one end 24a connected with the oil burner equipment through a passage 17a, said passage being formed in the shaft 26 as shown in Figs. 3 and 4. The opposite end 24b of said chamber is provided with a constricting baffle 35. Surrounding the chamber 24 and extending throughout the length of the stator structure, there is provided closely wound sets of concentrically arranged boiler tubes 36 spaced to provide communicating passages or flues 37 between each set of tubes. There is also provided a group of closely wound boiler tubes 38 between the end 24b of the chamber and a partition 25d. Said tubes 38 connect with the tubes 36 and serve as a superheater for the steam generated in the tubes 36. The passages 37 through which the gases of combustion pass from the chamber 24 extend through the superheater tube 38 and to and fro lengthwise the stator between the sets of tubes 36 as indicated by the arrows shown in Fig. 3. Said passages 37 terminate in inlets 39 at the gas turbine nozzles 40 for supplying the gases of combustion passing to the gas turbine 18, said gases after passing through the turbine blades 18a and 18b being exhausted at outlets 41. Thus the continuously burning fuel in the chamber 24 provides a heating medium for the superheater tubes 38 and the boiler tubes 36, and the gases of combustion passing said tubes after being greatly reduced in temperature are delivered to the turbine blades 18a and 18b for generating power.

The boiler 11 comprising the tubes 36 and 38 is of the flash or hot plate type, and may be constructed as shown in Figs. 3, 8 and 9. The boiler tubes 36 are seen to comprise an outer helically wound pipe 36a and a perforated inner helically wound pipe 36b extended centrally through said pipe 36a. The inner pipes 36b are supported within the pipes 36a in a substantially concentric position by any suitable means, as for example by spaced spiders 36c, the latter being made slightly smaller than the internal diameter of the pipes 36a to facilitate the assemble or removal of the pipes 36b.

The ends of the pipes 36b are end capped at 36d, adjacent the partition 25e, inwardly from the casing end 25a as shown in Fig. 3. The other ends of the pipes 36b of each set of tubes 36 may be interconnected by a manifold 42 which through a pipe 43 communicates with a feed water conduit 44, the latter extending through the channel 25c between casing 25 and shell 26^1. This manifold connection is located in the space 25f between

the partition 25d and the casing end 25b as is clearly shown in Figs. 3 and 6.

The water fed through the inner pipe 36b passes through spaced perforations 36e provided in the inner pipe 36b said perforations being preferably tangentially extending (see Fig. 9) for spraying the water against the inner heated surface of the outer surrounding pipes 36a. Thus the feed water will be flashed into steam which will pass through the pipes 36a into a header 45 and through pipe 46 into the inlet ends 38a of superheated tubes 38. From the outlet ends 38b of the superheated tubes 38, the steam passes through a pipe 47 to a live steam conduit 48, in the channel 25c. The conduit 48 communicates with nozzles 49 at the inlets of the high pressure turbine stage 12, see Figs. 3 and 8. After acting on the blades 12a and 12b, the steam passes through the outlet 50, and hence part of the steam into the inlet 51 of the low pressure turbine 13. A ring gland packed bearing 52 is extending from the rotor shell casing 28 separates the steam turbine in a high and low pressure turbine. The steam passing from the outlet 53 of the steam turbine enters the exhaust conduit 54 and passes through the passage 55 formed in the shaft 26 to the condenser 14.

A steam bleeder conduit communicates with the outlet end 50 of the high pressure steam turbine 12. Said conduit 56 through a passage 57 extending through the shaft 26 connects with the injector 15. The steam bled from the high pressure turbine is used by the injector to force the condensed water coming from the condenser 14 into the boiler 11 in the well understood manner.

The blower or air compressor 20 has inlet openings 29a formed in the rotor end plates 29. The air after being compressed passes through the outlet 58 into a channel conduit 59 and then through a pipe 59a is conducted into the combustion chamber 24 by means of a passage 60. Another passage 61 extends through the shaft 26 for supplying air to the oil burner 17 for vaporizing the liquid fuel sprayed through passage 17a into the combustion chamber 24.

A suitable ring packed bearing 63 may be provided to extend from the rotor casing 28 for separating the steam turbine 12 from the air compressor 20. A ring gland packed bearing 64 may also be provided for separating the steam turbine 13 from the gas turbine 18. It should be noted that the turbines are positioned relative each other so that the outlet 53 of the steam turbine 13 is adjacent to the outlet 41 of the gas turbine 18, thus the ring gland bearing 64 is subjected to a minimum difference of pressure. In a like manner, the gland bearing 63 of the high pressure steam inlet is positioned adjacent the outlet end 58 of the air compressor, so as to subject packed bearing 63 to a minimum difference of pressure.

Suitable valves 62 of any form which are open when stationary and closed if rotated may be provided for opening the interior of the apparatus to the atmosphere.

The operation of the apparatus 110 will now be apparent. From a conveniently positioned source corresponding to 16 shown in Figs. 1 and 2, crude oil is supplied to the burner 17. Said oil may be conditioned for efficient combustion by mixing same with air supplied through passage 61. The oil is sprayed into the combustion chamber 24 and burnt under pressure in the air supplied through passage 60 from the compressor 20. The gases of combustion leaving the chamber 24 pass through the superheater and flues 37 between the boiler tubes 36 in the direction indicated by arrows in Fig. 3. The superheater and boiler extract heat from said gases so that the temperature of the latter is dropped from about 1800° C. to approximately 1100° C. While much difficulty is experienced in building gas turbines to satisfactorily withstand operation with gases at 1800° C., at 1100° C., as in the apparatus here provided, such difficulties can be practically eliminated. The combustion gases at reduced temperature pass next to the turbine nozzle 40 and through the blades 18a and 18b converting much of the heat energy in the gases into available mechanical energy in turning the rotor. The temperature of the gases exhausted at the turbine outlets 41 will be lowered to approximately 200° C.

The steam generated in the boiler tubes 36 is superheated in tubes 38 and passes to and through the high pressure stage 12, to the outlet 50. Next the steam passes to the low pressure turbine stage inlet 51, through the low pressure stage 13 to the outlet 53. Before the steam passes to the low pressure stage, about 80% of the steam flowing is bled off into conduit 56, through passage 57 in the shaft 26 to the injector 15.

If the boiler is operated at 800 lbs. pressure per square inch, the steam bled from the turbine will be about 200 lbs. pressure per square inch. This bled steam is expanded in the injector 15 to force the condenser water back into the boiler.

The exhaust steam passes from the low stage turbine outlet 53, through channel conduit 54 and the passage 55 in the shaft 26 to the condenser 14. Said condenser

may be of relatively small size since in the present arrangement it is required to handle only about 20% of the steam generated, the remainder being bled off as described above and returned to the boiler by the injector 15. The energy extracted from the steam is transmitted to the rotor and together with that produced by the gas turbine 18 is made available through the extension sleeve 30a which connected with the propeller 23 through the transmission 19 and gears 22. It is contemplated with the power plant herein described to operate the units so that the gas turbine 18 normally provides at least 40% of the total power generated.

The air supply is furnished by the turbine type air compressor 20 having an inlet at 29a and outlets through passages 60 and 61 to the combustion chamber 24 and oil burner 17, respectively, as has been described above, the air pressure in said chamber 24 being preferably maintained to correspond to several atmospheres.

It will now be seen that there is provided devices in which the several objects of this invention are achieved and which are well adapted to meet the conditions of practical use.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. In a power plant of the character described, the combination of a boiler and a turbine, said boiler having means thereon serving as a stator for the turbine.

2. A power plant according to claim 1, including an external rotor surrounding the stator, and cooperating means carried by and extending between the stator and rotor forming the steam turbine, and means connecting the boiler with said turbine.

3. A power plant according to claim 1, including an external rotor surrounding the stator, a plurality of sets of cooperating means carried by and extending between the stator and rotor forming a gas and a steam turbine, steam connecting means between the boiler and steam turbine, and gas connecting means between the boiler and the gas turbine.

4. A power plant according to claim 3, including a set of cooperating means carried by and extending between the stator and rotor from an air compressor, and means connecting the air compressor to the boiler.

5. A power plant according to claim 2, including steam-operating means for feeding water to the boiler, and means for bleeding the turbine to provide steam for said water feeding means.

6. A power plant according to claim 1, including a flash boiler construction having an outer steam tube, an inner water tube, means for supporting the water tube substantially concentric within the steam tube and spaced tangentially positioned perforations in said water tube wherethrough the water is sprayed against the inner surface of the steam tube.

7. A power plant substantially as shown, described and for the purpose set forth.

Dated this 5th day of February, 1931.

For the Applicants,

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Chartered Patent Agents.

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Fig. 1.

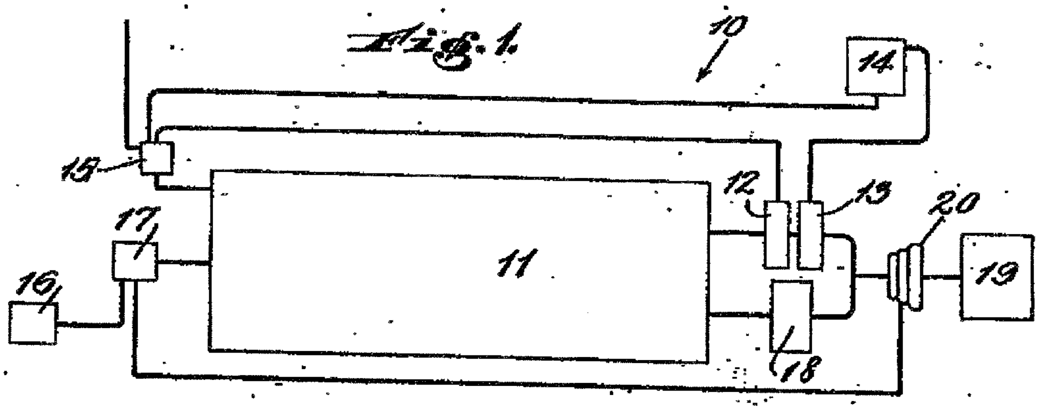


Fig. 2.

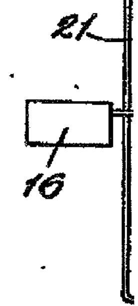
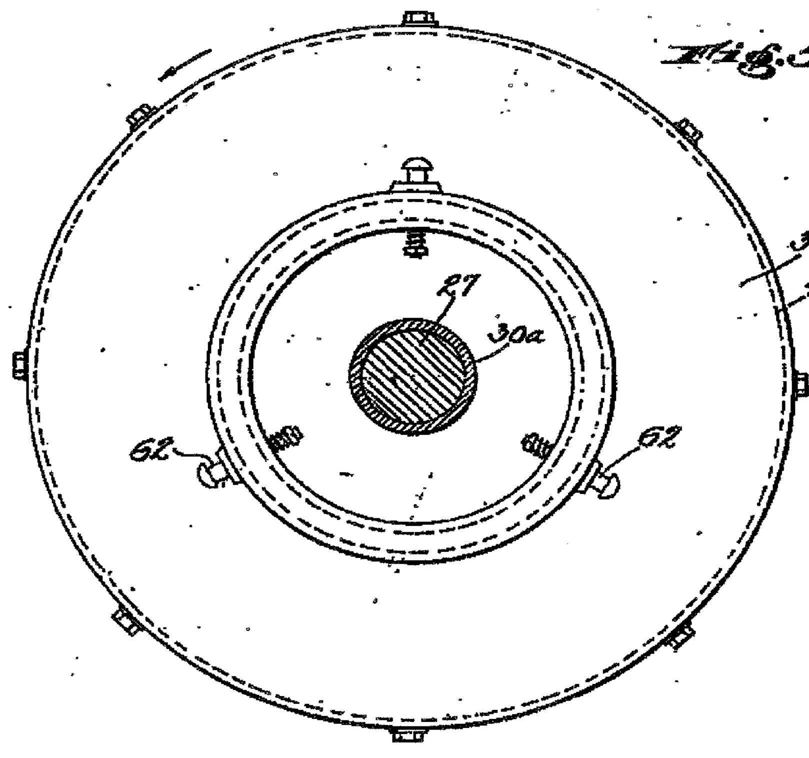


Fig. 5



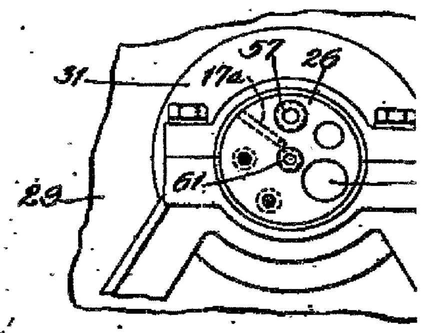
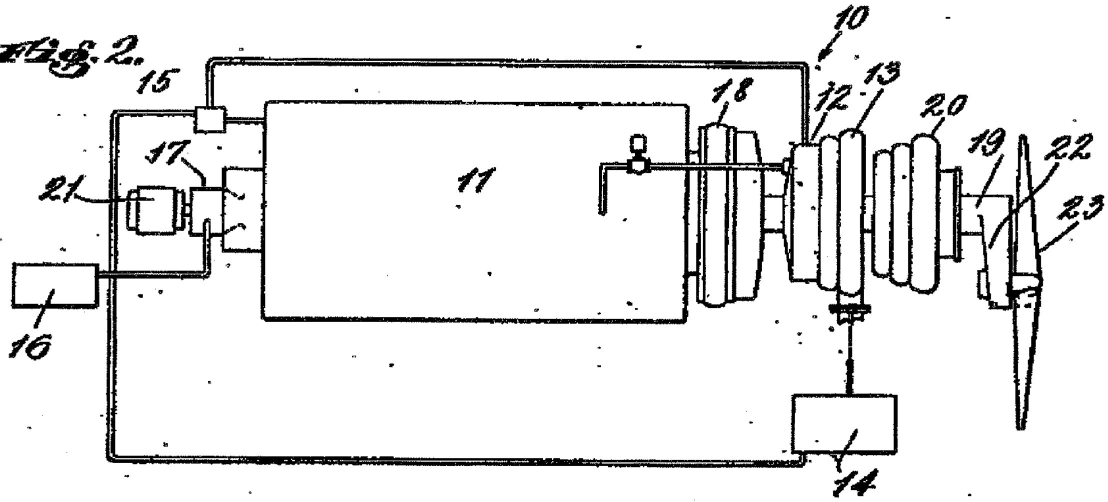


Fig. 4.

Fig. 2.



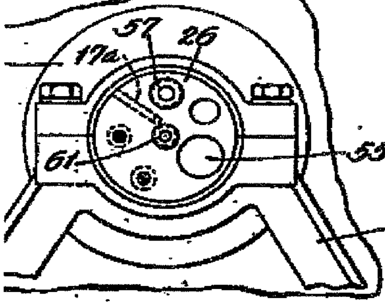
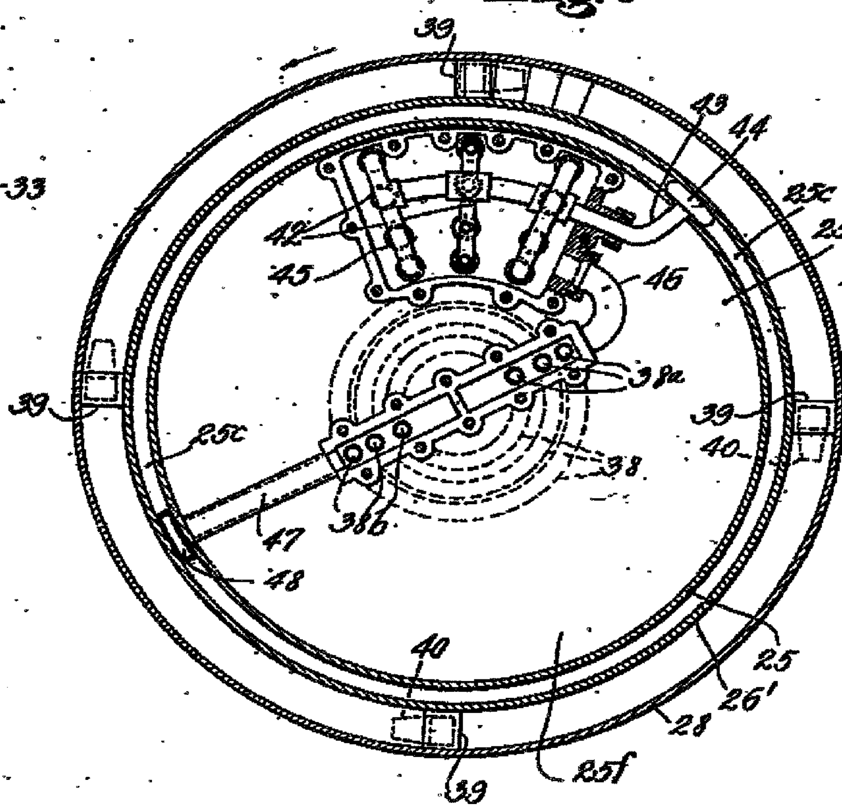


Fig. 4

Fig. 6



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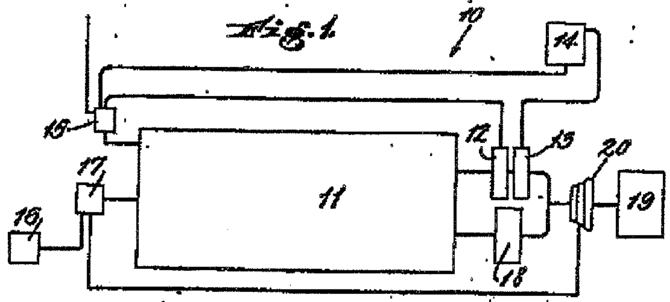
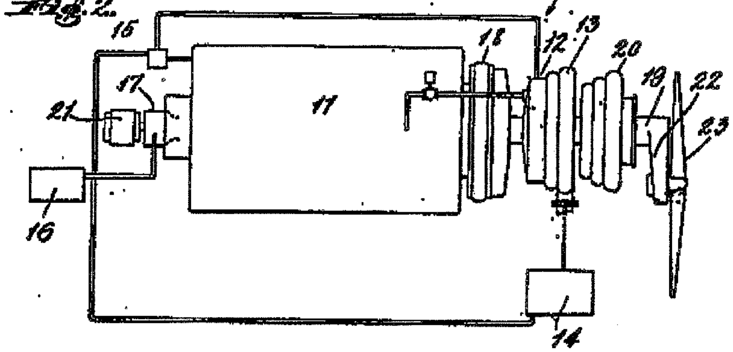


Fig. 1.

Fig. 2.



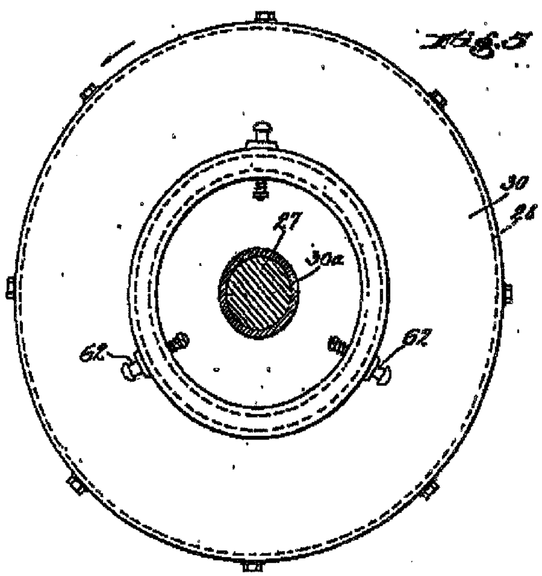


Fig. 5

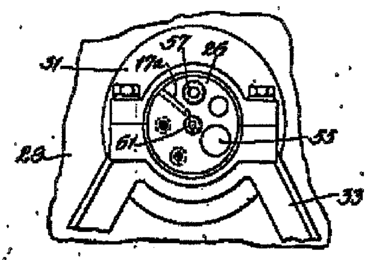


Fig. 4

Fig. 6

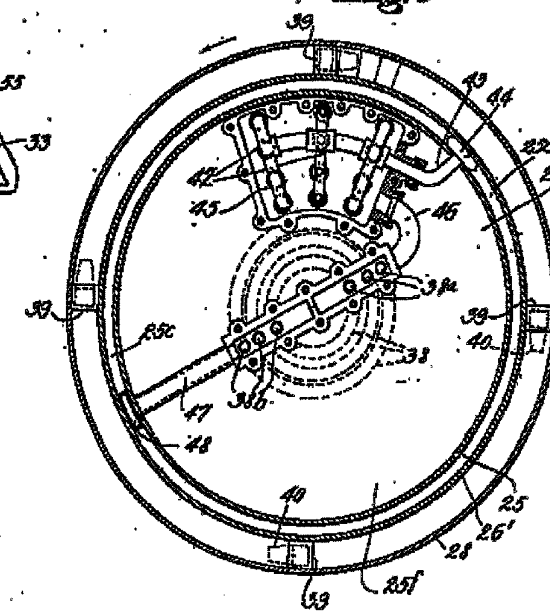


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Fig. 3.

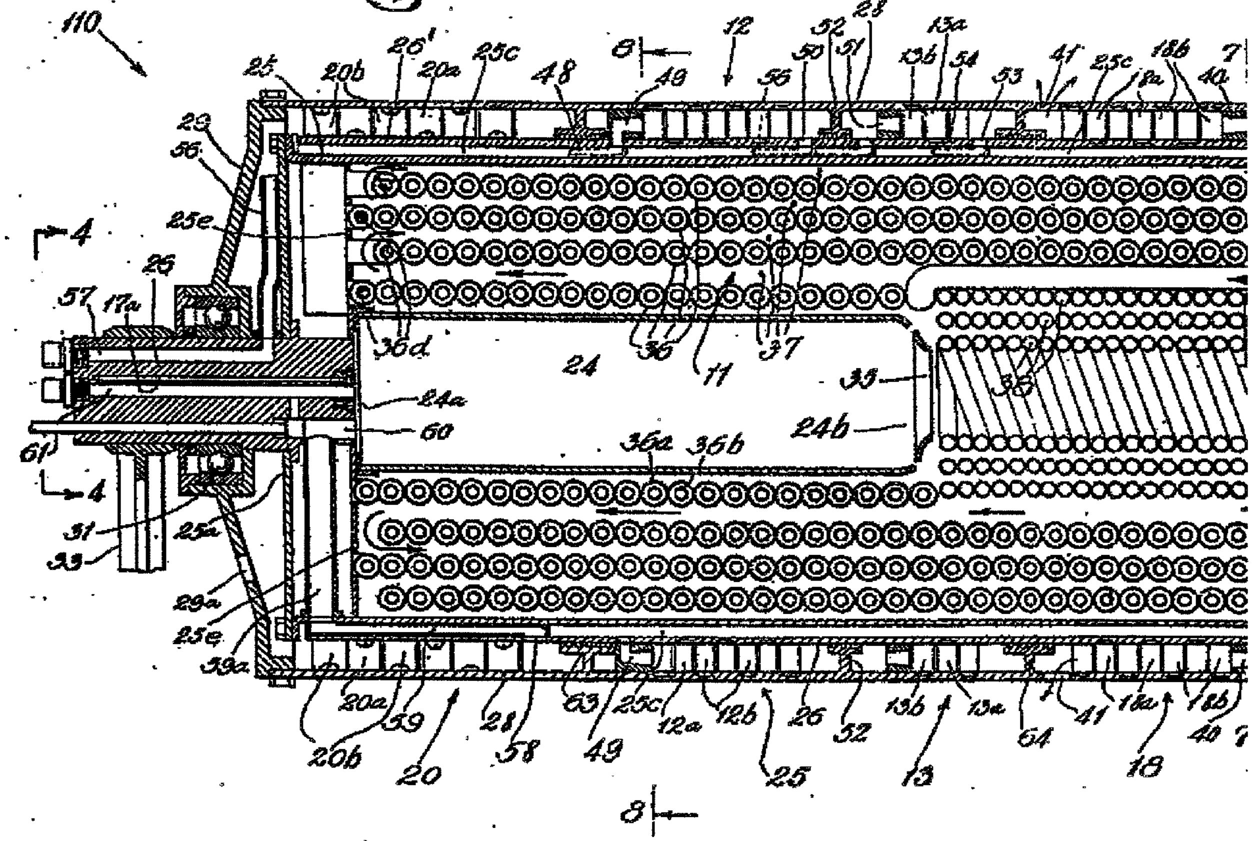
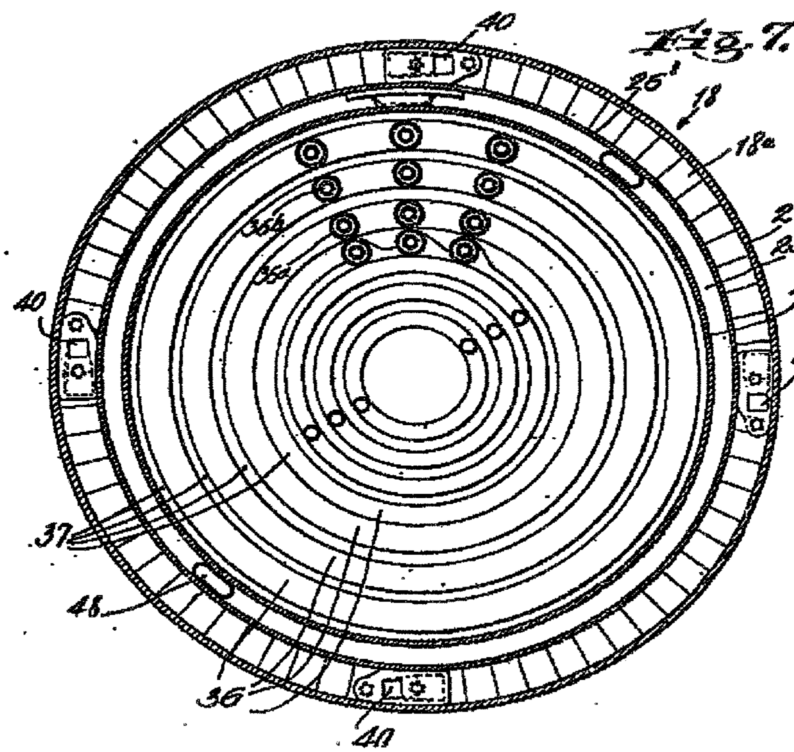


Fig. 7.



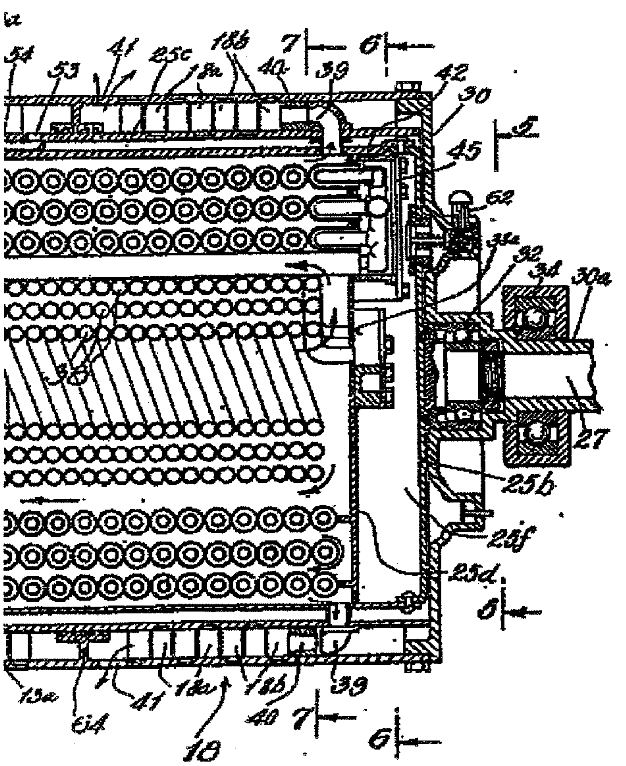


Fig. 9.

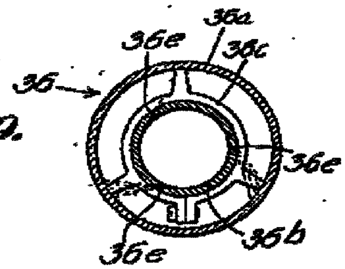


Fig. 7.

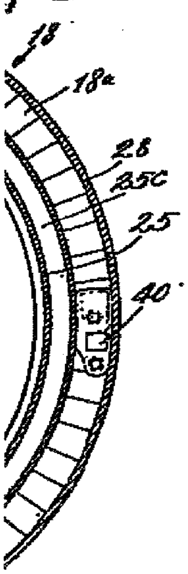


Fig. 8.

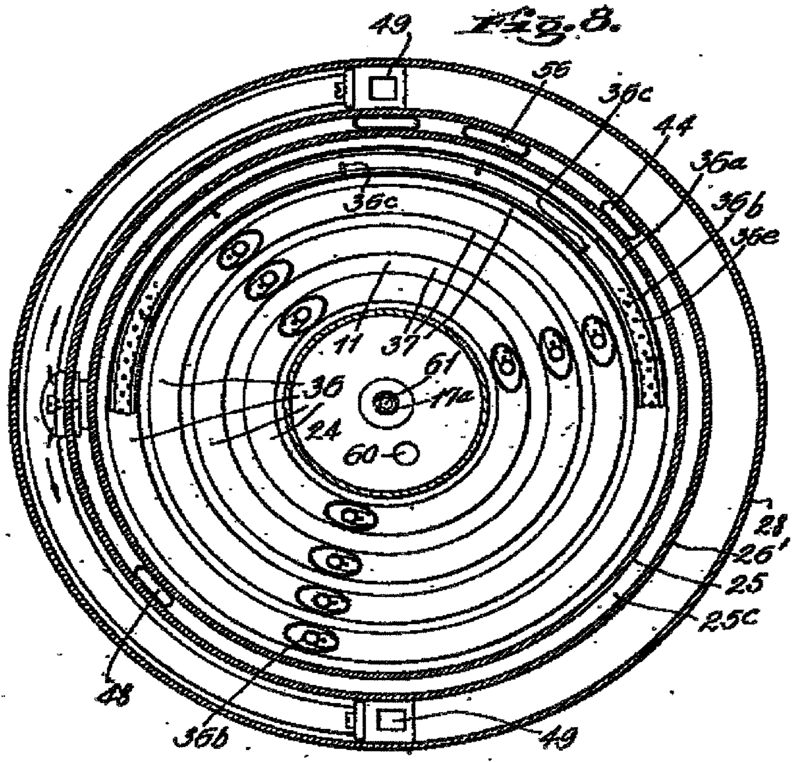


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Fig. 3.

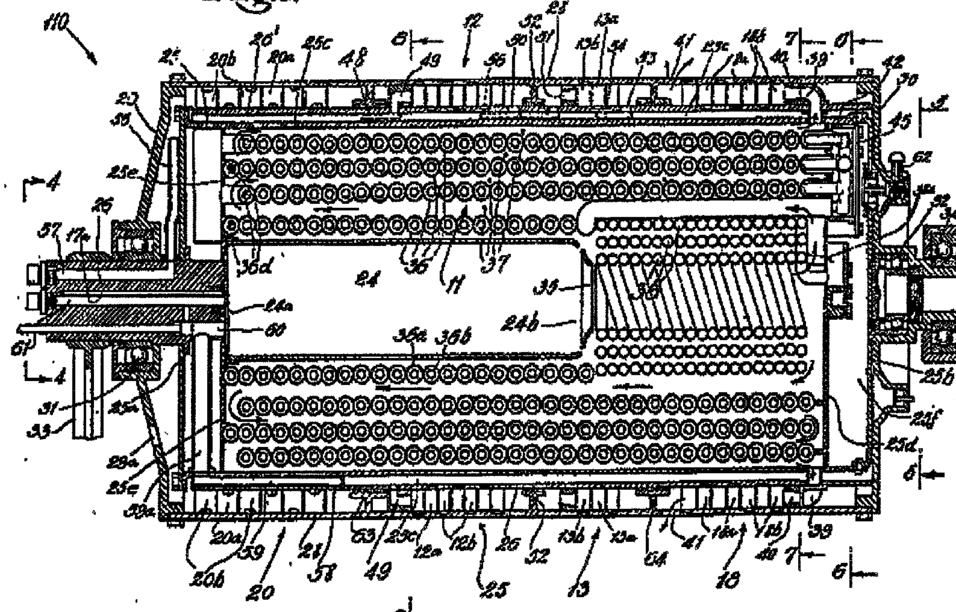


Fig. 9.

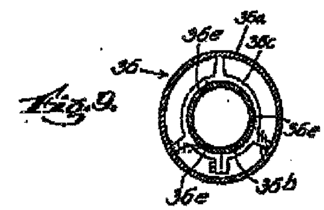


Fig. 7.

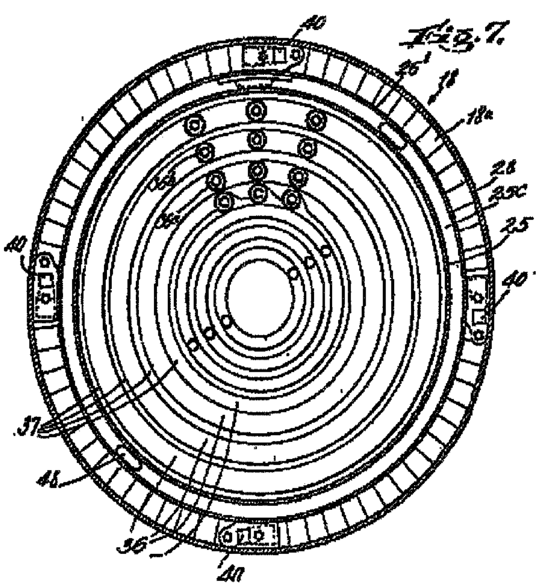
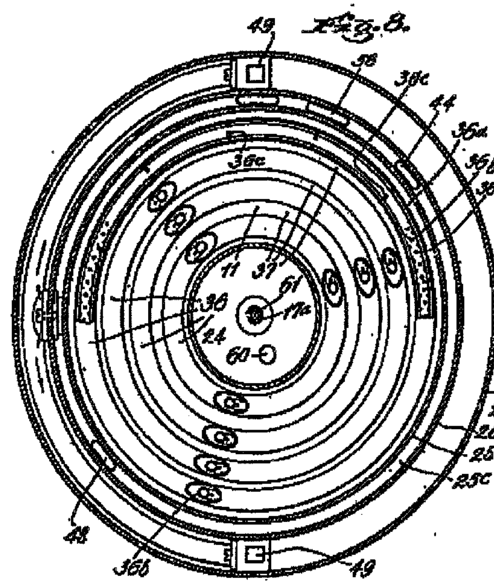


Fig. 8.



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